Screening sunscreens: protecting the biomechanical barrier of skin from ultraviolet radiation damage

The uppermost layer of human skin, known as the stratum corneum (SC), is the most important physical barrier between the human body and the environment and plays a surprisingly acute role in the mechanical function of full thickness skin (Fig. 1).

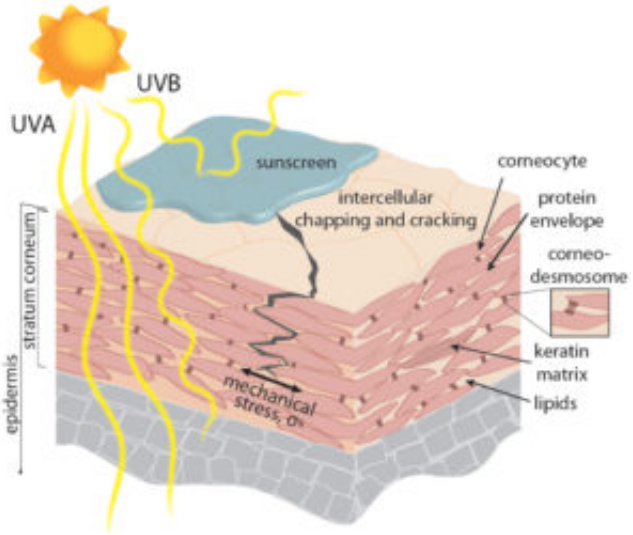

Fig. 1. Schematic of the structure of the stratum corneum.

UV exposure has dramatic effects on the cellular cohesion and mechanical integrity of SC. When exposed to UV radiation, the inherent mechanical stress in the SC increases, while at the same time the resistance to damage in the form of cracking and tearing decreases. While current FDA approval for sunscreens relies mainly on their ability to prevent erythema, it is unclear if sunscreens can maintain the mechanical barrier properties of skin, an often overlooked but essential function for life. Compromised barrier function results in ubiquitous skin damage like chapping and cracking, and more serious and even life-threatening conditions related to infection, chronic wounds and skin lesions. We found *in vitro* thin film mechanics techniques are able to fill in this gap in knowledge by characterizing the ability of commonly used commercial sunscreens to protect the biomechanical barrier properties of SC from UV damage.

For a control sample of SC with no UV exposure, internal drying stress plateaus at ~6 MPa within several hours. After a 100 J cm^{-2} UVA exposure, the drying stress profile dramatically changes. The stress starts increasing sooner and rises to a 44% higher plateau value than in the case of the control specimen. However, in the case of SC treated with ZnO/TiO_2 based sunscreen, the UVA exposed and non-exposed curves lie much closer together, indicating a large reduction in UV

damage to the SC (Fig. 2a).

A direct measure of the tissue's resistance to cracking is given by the delamination energy of the SC, or the energy required to separate intercellular boundaries. Without sunscreen, specimens exhibited significantly lower delamination energies with UVB exposure, suggesting decreased cohesion of the corneodesmosomes and intercellular lipids with UV radiation. However, with ZnO/TiO_2 based commercial sunscreen applied, the delamination energy for UVB exposed and non-exposed tissue showed no significant differences (Fig. 2b), even up to a large dose of 500 J cm^{-2} UVB, equivalent to ~38 days of solar exposure.

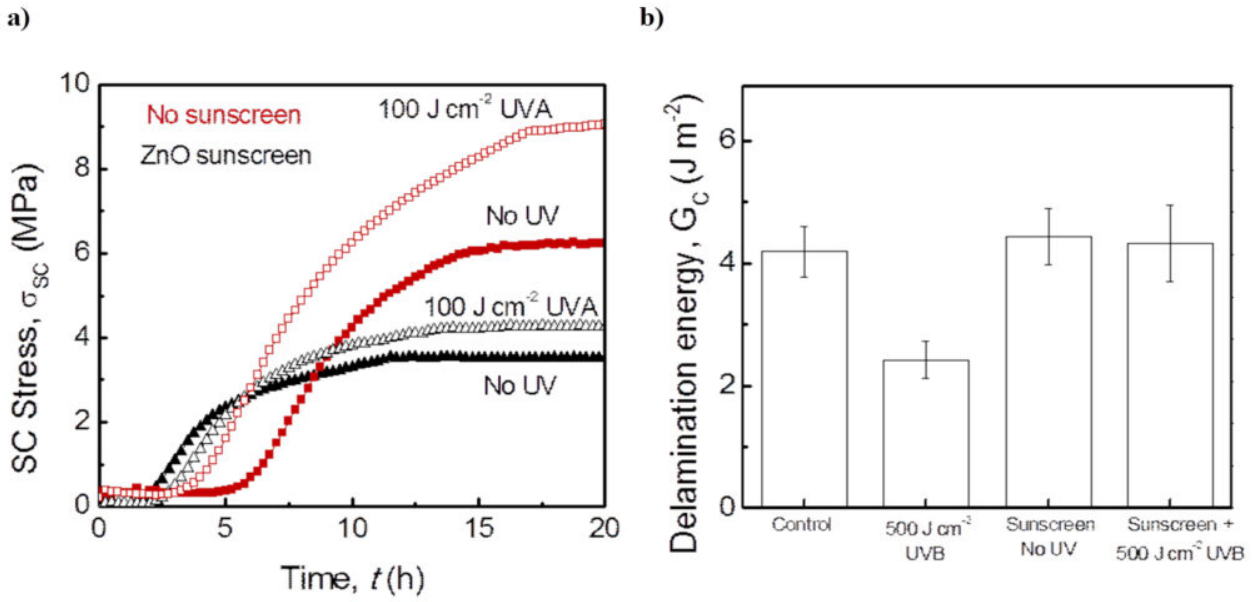

Fig. 2. (a) Drying stress of fully hydrated SC placed in a dry environment. (b) The delamination energy for UVB exposed and non-exposed tissue.

Our *in vitro* thin film mechanics techniques adapted for biological tissue demonstrated that the sunscreens tested were effective at protecting the mechanical properties of the SC, namely its inherent mechanical stress profile and cellular cohesion, from UV damage. We intend that the biomechanical properties studied here (and the techniques used to study them) will be added to the cadre of other commonly used though less quantitative indicators of solar protection in order to form a more complete understanding of UV protection through sunscreen.

Christopher Berkey, Krysta Biniek, Reinhold H Dauskardt
Department of Materials Science and Engineering, Stanford University, Stanford, CA, USA

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